EXPRESSION OF THREE DIMENSIONAL SPACE WITH DIGITAL CARTOGRAPHIC DATA AND COMPUTER GRAPHICS METHOD

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ABSTRACT:

Expression of three dimensional space with digital cartographic data and computer graphics method have been studied in the Geographical Survey Institute of Japan since 1994. This trial has been carried out as one of the research for next generation map. So far, we have studied data producing method, three dimensional model generation method and trial of making realistic landscape images so as to consider the data contents of next generation map. A few kinds of results for the realistic expression of three dimensional space were obtained. This paper describes the process of creation of three dimensional landscape view and their results.

1. INTRODUCTION

In conventional topographic maps printed on paper, real three dimensional world is projected vertically onto two dimensional plane with symbolization of ground objects. This expression demands some knowledge and skills to read maps. It also has some problems especially in representing urban area where many elevated roads and underground passages exist.

We are trying to study new representation method for three dimensional space, according to human's custom and ability concerning about 3-D space recognition. Digital cartographic data opens up possibility of completely new expression of maps. By utilizing computer graphics technology, landscape image from arbitrary viewpoint can be generated. Animation movement of viewpoint is also possible. The expression makes it easy for general users to recognize three dimensional space.

2. METHOD OF THE STUDY

There are two research items in this study. One is to study the method to create realistic landscape image from digital cartographic data. The other is to examine data contents of digital cartographic data required for such representation.

Cartographic data corresponding to 1:25,000 Topographic Maps published by the Geographical Survey Institute(GSI) are used as the first target because they are the largest scale maps covers all of Japan. As for data items, digital elevation data(DEM) and main road data of 1:25,000 scale topographic maps produced by the GSI and houses and field boundary data picked up with a digitizer are used.

So far, we have studied about data contents and realistic expression for three dimensional space by using Computer Graphics (CG) technology with personal computer or graphic workstation. As results, we can got some kind of realistic landscape static scene of Mt. Tsukuba, which is small mountain but famous as sightseeing place in Japan, rendered by various kind of CG method, for example flat shading, phong shading, texture mapping and bump mapping, to express for more reality. We also created animation of Mt. Tsukuba area for more realistic expression of three dimensional space. The study of map representation for three dimensional space written in above was presented at the 17th International Cartographic Conference in 1995. These results have brought many capabilities of new map representation. But some problems have been found in this study. So, we have been continuing to study to cope with these problems and for more realistic expression.

2.1 Digital cartographic data produced by GSI of Japan and data preparation

Geographical Survey Institute has been producing several kinds of digital cartographic data. We used these digital cartographic data for this study as a structure of three dimensional space.

Some kind of information, for instance, vegetation boundary, houses and buildings data of 1:25,000 topographic map are not prepared in present. So we have to collect these data from conventional topographic map with a digitizer.

Large scale cartographic data obtained from Digital Mapping data produced by GSI was used.

2.1.1 50m mesh DEM

GSI have been producing digital elevation model(DEM) in the whole country. These are about 250m grid interval (mesh) DEM and about 50m grid interval (mesh) DEM. We used this 50m grid interval DEM to make terrain model.

2.1.2 Road data(main road)

GSI also produces digital road data. However, only main road data administrated by the national government and so on are available at the moment.

2.1.3 Houses and buildings

GSI does not produce digital cartographic data of houses and buildings corresponding to medium scale maps. They have to be collected with a digitizer from medium scale topographic maps manually.

2.1.4 Vegetation boundary

Vegetation boundary is the most important data to express realistic landscape images. However, GSI have not produced vegetation boundary digital data of medium scale maps. We have to get digital data by using the same method as houses and buildings data collection.

2.1.5 Water boundary

Water boundary is also collected by digitizing with a digitizer from 1:25,000 scale topographic map.

2.1.6 Large scale data from Digital Mapping data

Large scale houses, road boundary and water boundary etc. From digital mapping data are used for expression of large scale scenery.

2.2 Creation of three dimensional space model

After preparing digital cartographic data, three dimensional space model are generated by using DEM. This process is carried out automatically with batch program. This three dimensional model can be converted to DXF, so if we would like to edit details of the model, we can use CAD system for it.

2.3 Visualization of three dimensional space by using Computer Graphics method

After creating three dimensional model, we have to paint color to each polygon structuring three dimensional model. Each polygon has identity number according to its category, and each polygon can get identical color by using computer graphics method and technology. First of all, the surface model are created from three dimensional space model. Shadow and lighting are calculated to make surface model. After this, to make more realistic view, texture is mapped onto surface of 3-D model. Texture can be created from scanned photographs. Behind landscape, we can put an image of clouds made from a photo. We can also use bump map method to express surface of model. Bump mapping is effective to express rough surface. We can also express a variety of landscape images by changing the textures. For example, if we use a picture of snowing, scenery of winter can be expressed.

3. EXPRESSION WITH DATA OF LARGE SCALE MAP

In this study we had been using digital cartographic data collected from 1:25,000 scale topographic map mainly. But this scale data can hardly express small objects such as houses, buildings and so on. So, we have tried to use digital mapping data on a scale of 1:2,500 in order to express small objects such as houses and buildings individually. Digital mapping data of houses and buildings have X Y coordinates in two dimensional space, but Z coordinates are not prepared in digital mapping data. We need height information of houses and buildings to express three dimensional space from the digital mapping data. Therefore, we put height information of houses and buildings onto digital mapping data to create three dimensional model. Roof shape attributes were also created to express house details. Three kind of roof shape namely flat roof, kirizuma roof (triangle cylinder shape) and Yosemune roof (pyramid style shape) are modeled for more realistic expression of houses and buildings.

We also try to express some kinds of three dimensional space about built-up area or urban area with large scale digital cartographic data for the purpose of expression of the details. Fuji city in Shizuoka prefecture which is located in middle of Japan was selected as a test areas. The population of Fuji city is about 240,000. The center of the city is built up with many old house made of wood and some buildings which height are less than 10 stories. Fuji city has created digital mapping data for whole area of the city on a scale of 1:2,500. We used the digital mapping data for our study. We selected center area of the city including the city hall as a test area(**Figure 1**).

Digital data structure of road of digital mapping data are different from 1:25,000 scale cartographic data. Data of block area are collected in this large scale digital data, that is to say boundary between road and block are dizitized. Owing to this data structure, it is possible to create every kind of street as compared with 1:25,000 scale digital topographic map.

These methods bring a little effect for expression of details. But it is not enough to express details. Some special items, for instance, tree in backyard or park, advertisement board, telegraph pole etc are very important for the expression of urban area. Usually, these special items are not prepared in general digital cartographic data. We found results of our study dose not express a built-up area of ordinary Japanese city.

4. EXPRESSION OF GEOGRAPHICAL FEATURES FOR STEEP SLOPE

It is difficult to express cliffs and river banks in middle scale

topographic maps such as 1:25,000 scale topographic map with only DEM or contour line. So we express steep slopes by using special map symbol in conventional topographic map printed on paper. In this study, we selected Lake Chuzenji-ko and Mt. Nantai-san area in Tochigi prefecture and tried to express cliffs, bank, steep slopes and so on in the expression of three dimensional space(**Figure 2**,**Figure 3**).

5. MAP ANNOTATIONS

There have been a problem of how to express annotations in three dimensional space. It is one of the most important matter as map expression. We not only need three dimensional landscape or realistic expression as new map representation method but also a variety of information as useful map or geographical information. Representation of annotations is one of the most important matter to convey much information hidden in a map. Therefore, we have been developing a method to express annotations onto the three dimensional space of map. Map annotaitions are embedded in the three dimentional space as line data. These can be shown in the perspective view.

6. OTHERS

We also have been trying to use some other kind of map representation. Digital Orthophoto data made from Satellite images or aerial photographs have been used for different expression. These satellite images or aerial photographs were stuck on the three dimensional model. This method can create realistic expression of three dimensional space easily. But it cannot represent three dimensional objects like houses or buildings on the field. Therefore houses and buildings are expressed as 2D images.

Whole flow of the study is shown in **Figure 4**.

7. CONCLUSION

These new methods for map expression bring a lot of capability and information for us. We can expect that this method can be used for many purpose, for instance, environment assessment, development planning of regional scale and countrywide scale, city planning, landscape analysis, and others. But some problems are realized in this study.

Before creating three dimensional model, we have to create two dimensional polygon structure from each cartographic data. However, usual cartographic data such as digital mapping data do not have topological structure. Topological data preparation is important to create three dimensional data with ease.

We have to consider how we should digital cartographic data having three dimensional data structure with supporting of data structure and data item for the purpose of many kinds of utilization in the future.

REFERRENCE

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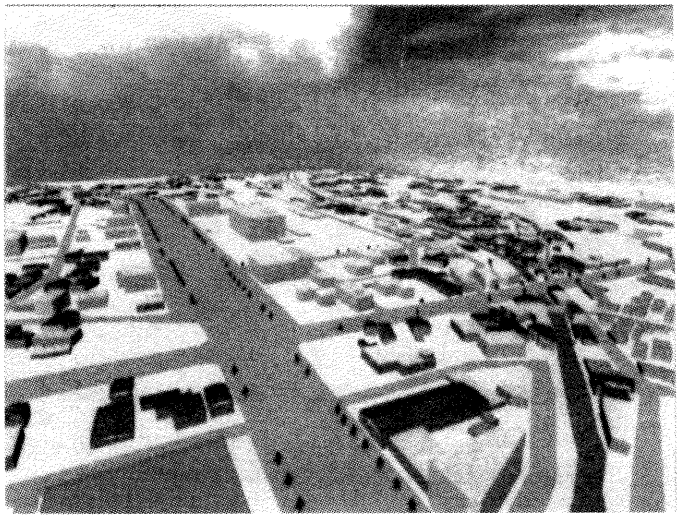

Figure 1 Landscape of Fuji City

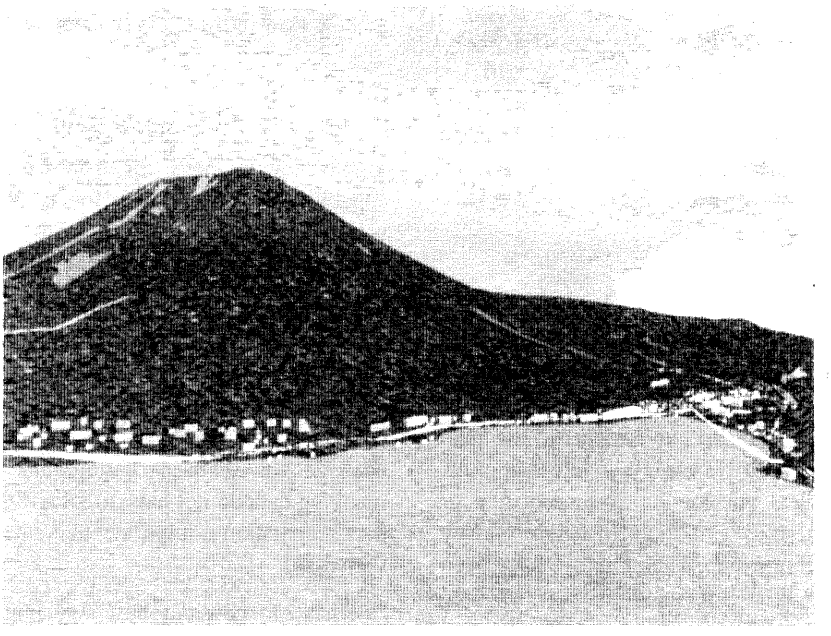

Figure 2 Landscape of Lake Chuzenji-ko and Mt.Nantai-san

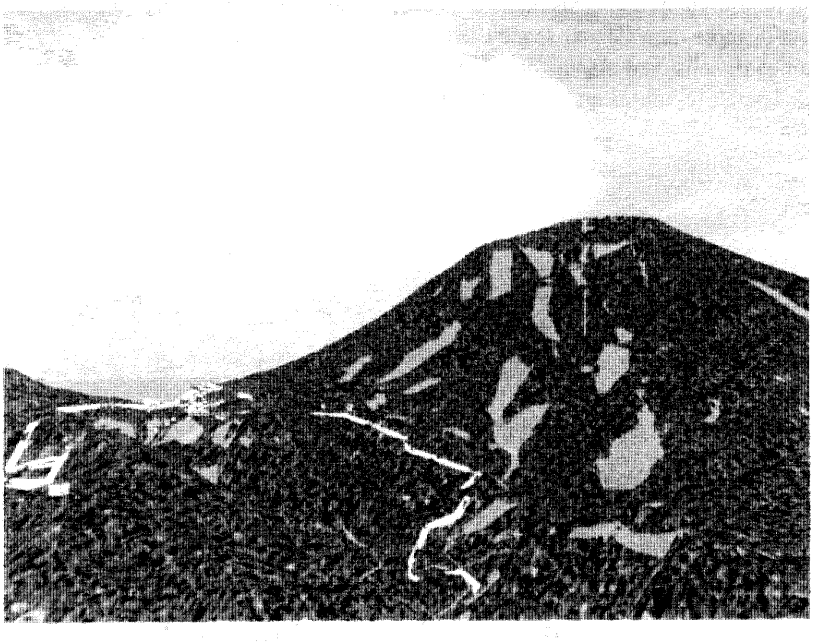

Figure 3 Landscape of cliffs and steep slopes

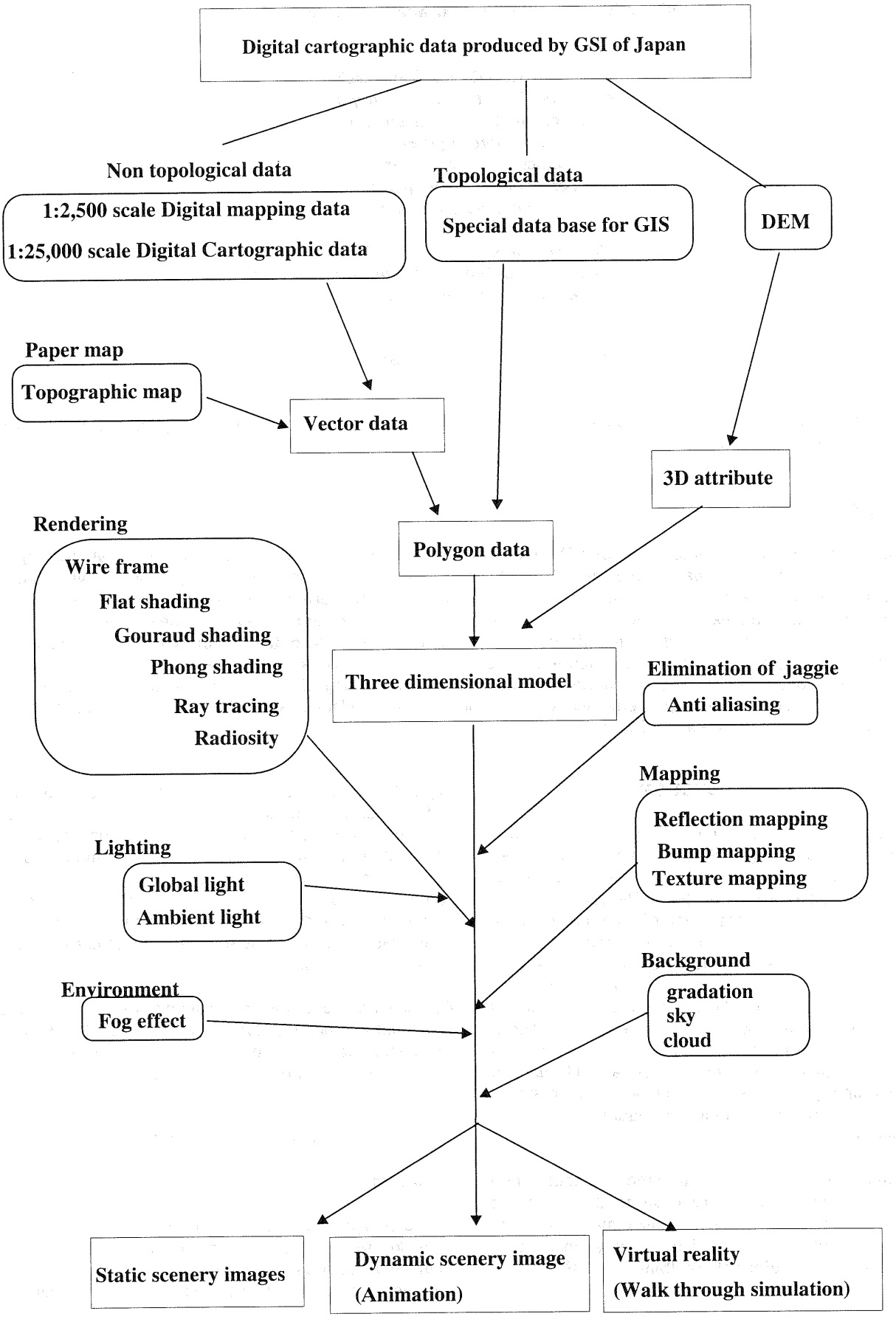
Digital cartographic data produced by GSI of Japan
Non topological data
1:2,500 scale Digital mapping data
1:25,000 scale Digital Cartographic data
Topological data
Special data base for GIS
DEM
Paper map
Topographic map
Vector data
3D attribute
Rendering
Wire frame
Flat shading
Gouraud shading
Phong shading
Ray tracing
Radiosity
Polygon data
Three dimensional model
Elimination of jaggie
Anti aliasing
Mapping
Reflection mapping
Bump mapping
Texture mapping
Lighting
Global light
Ambient light
Background
gradation
sky
cloud
Environment
Fog effect
Static scenery images
Dynamic scenery image
(Animation)
Virtual reality
(Walk through simulation)

Figure 4